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(54) Tubing hanger and tree with horizontal flow and annulus ports

(57) A well production assembly includes a production tree (41) which has a lateral production passage (49) extending laterally from a vertical production bore (59) of the tree. A tubing hanger (57), also having a lateral production passage (61), lands in the tree, with the lateral passages registering with each other. The junction of the lateral passages has flat, inclined, sealed areas which mate with one another. An annulus passage (67) extends vertically through the tubing hanger (57) offset from and parallel to the tubing hanger vertical production passage (31). The annulus passage also has a lateral passage (69) which registers with a lateral passage (53) formed in the tree. The annulus lateral passages have a flat, inclined seal area at their junction. The tubing hanger has a downward facing hydraulic connector which registers with an upward facing hydraulic connector located on a shoulder formed in the bore. Once mated, the connectors provide hydraulic or other auxiliary fluid communication to downhole equipment. These auxiliary passages and connectors are located within the body of the tubing hanger. The well production assembly is also provided with offset production and annulus plugs (73, 75).

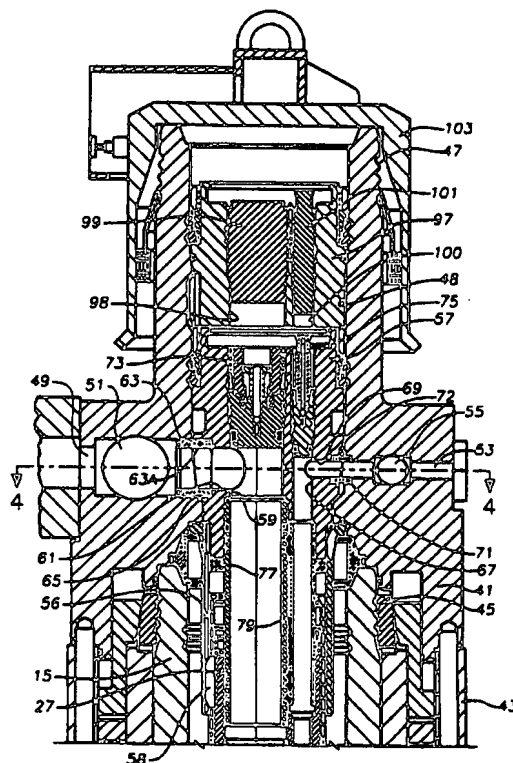


Fig. 1A

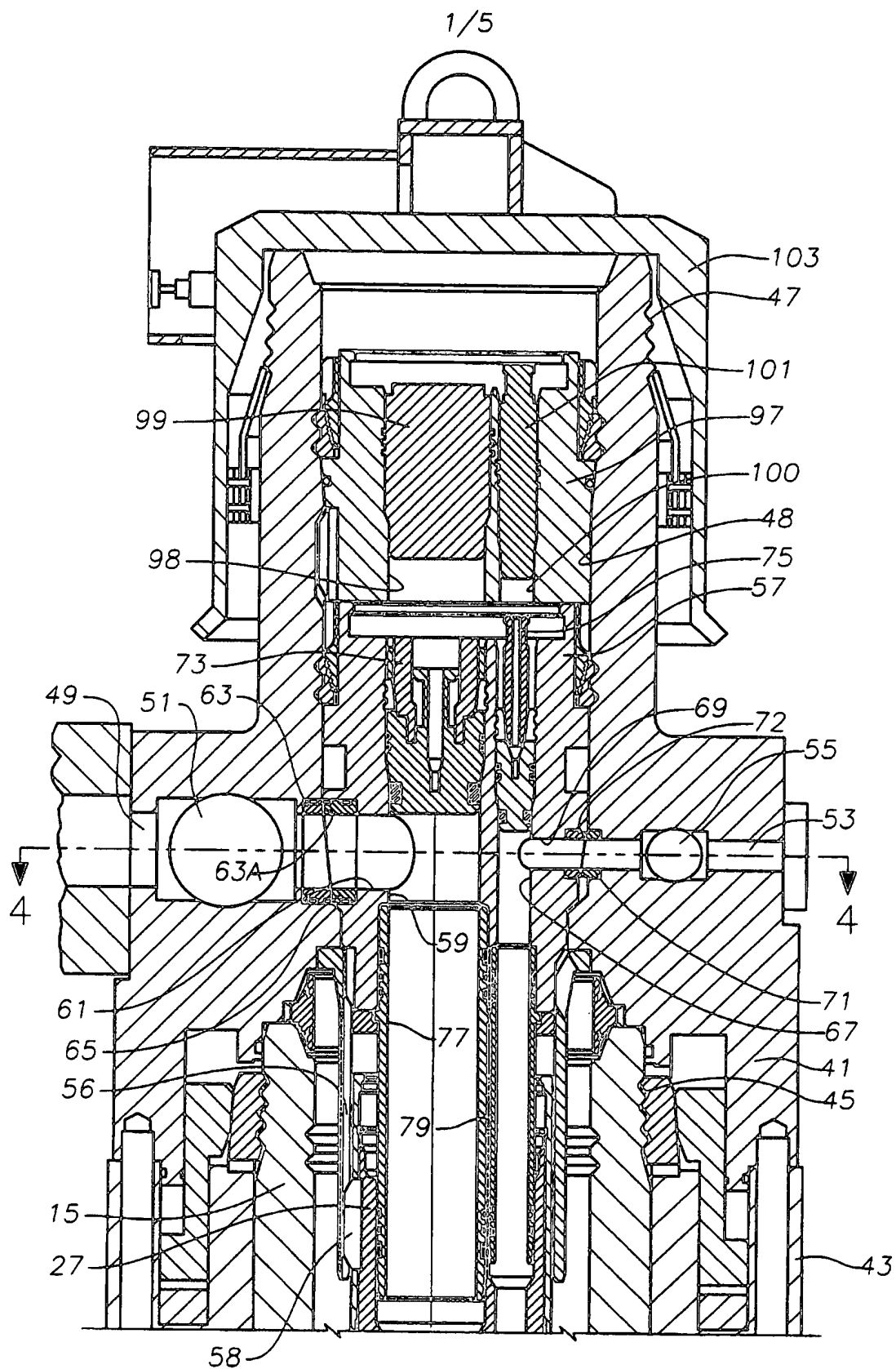


Fig. 1A

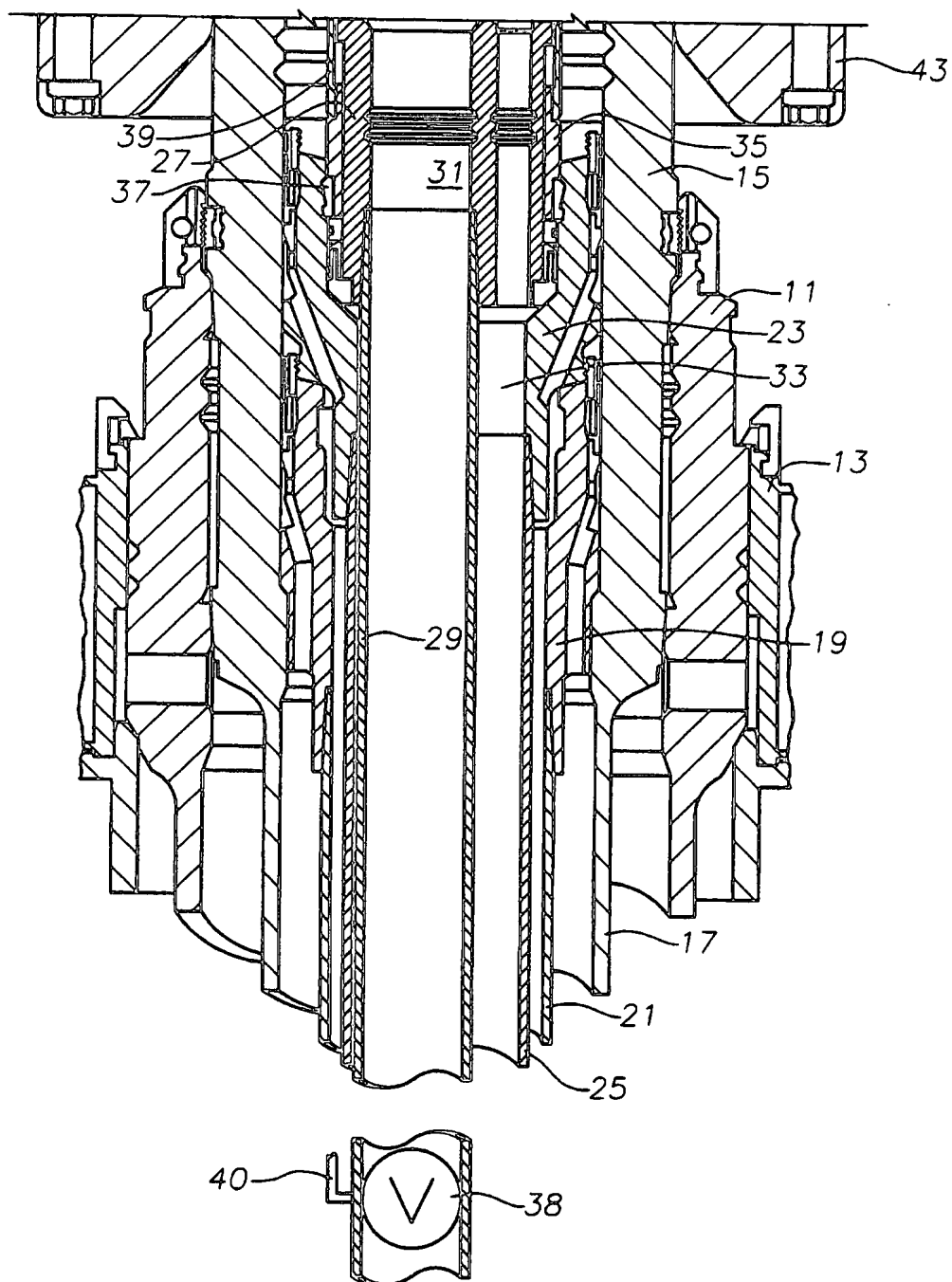


Fig. 1B

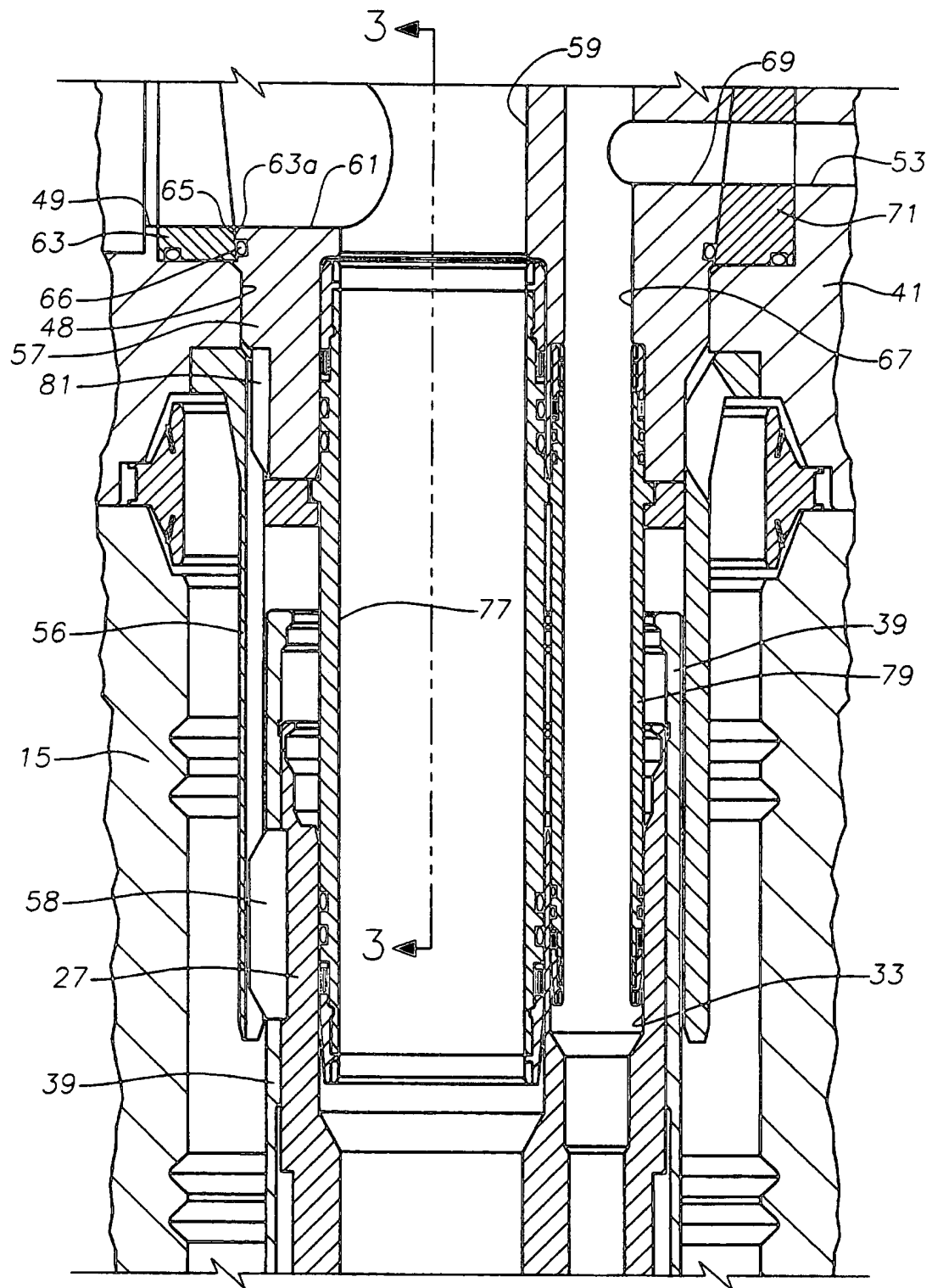


Fig. 2

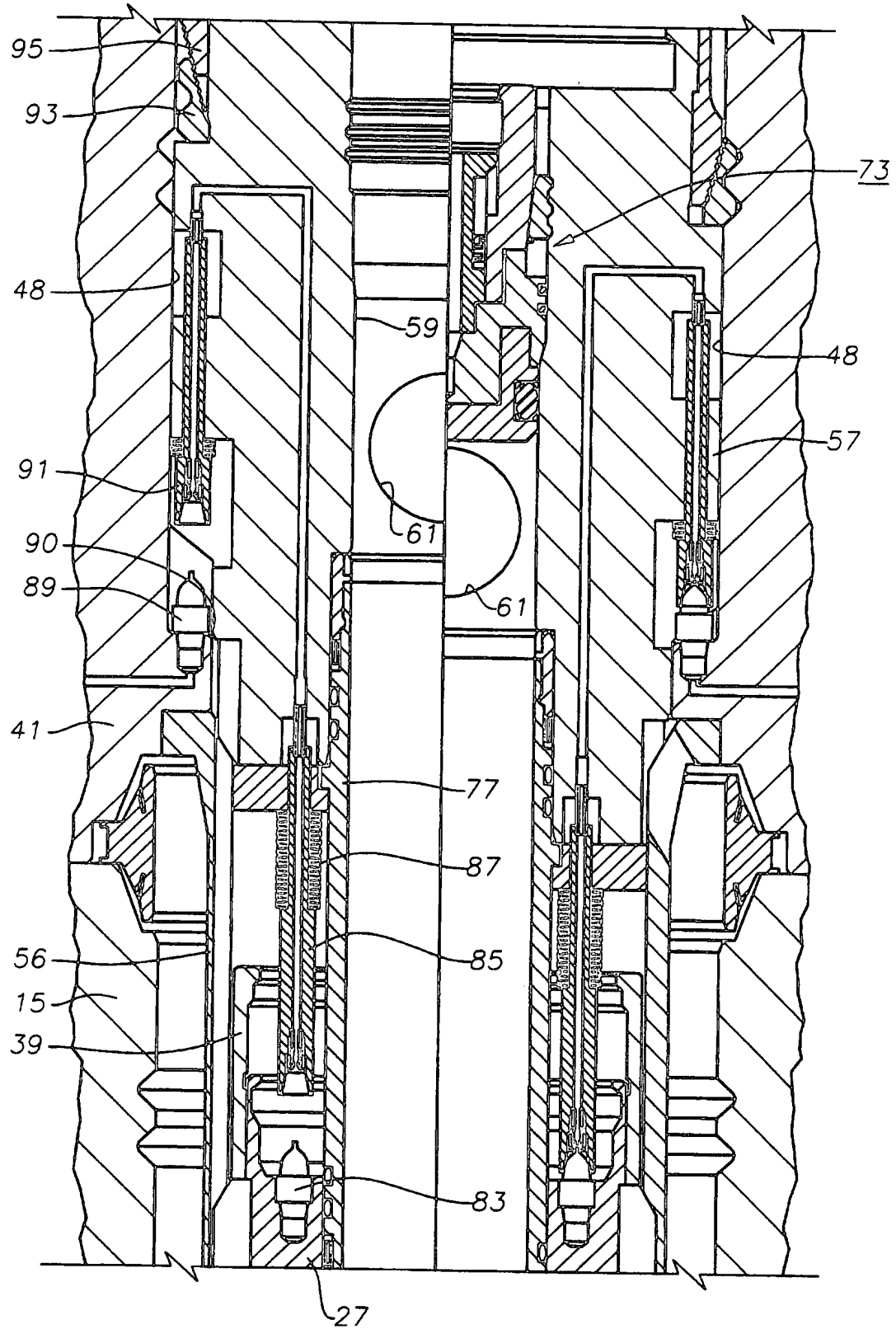


Fig. 3

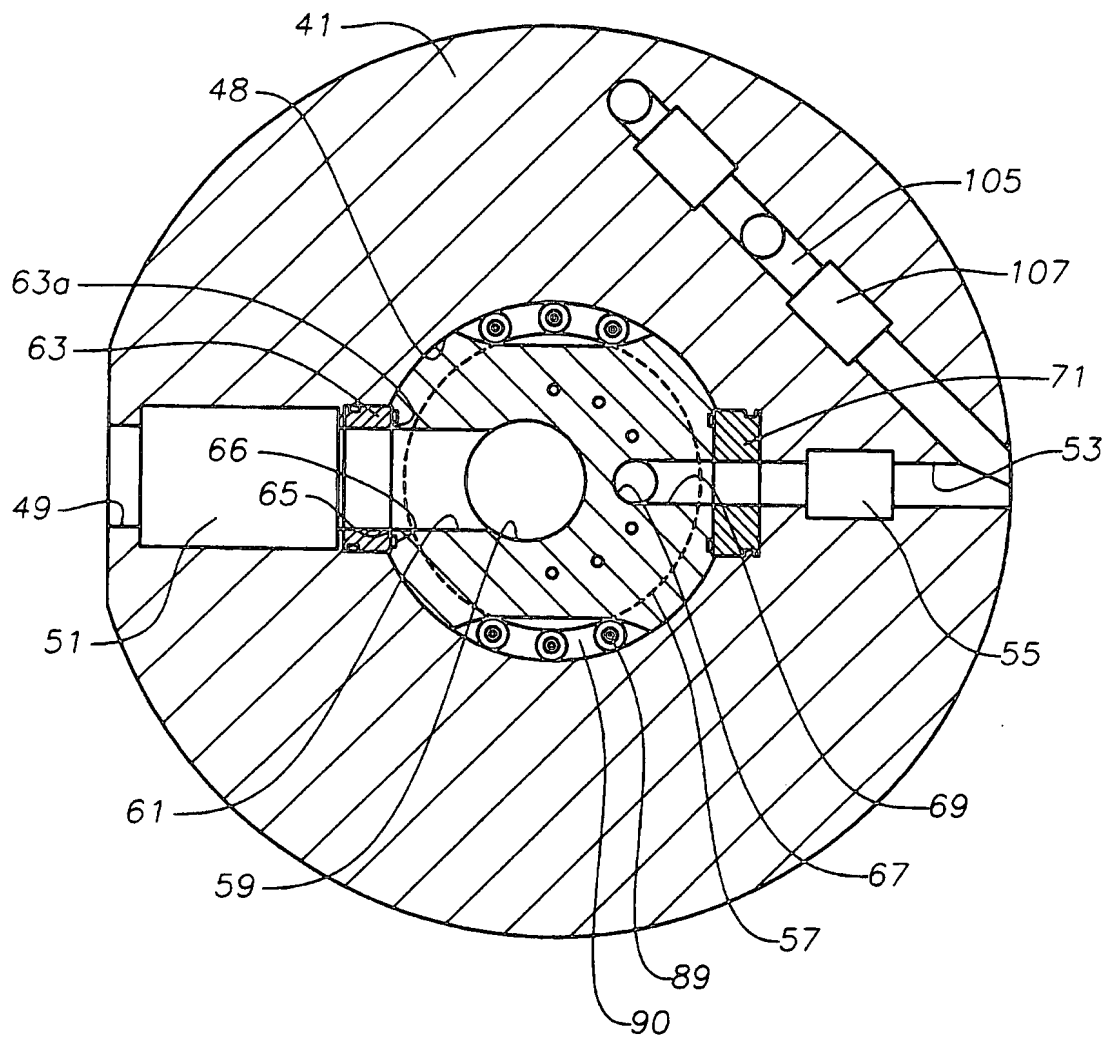


Fig. 4

1 Docket No. 174-96025  
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8 TUBING HANGER AND TREE WITH HORIZONTAL FLOW  
9 AND ANNULUS PORTS

10 Inventor: Philippe Nobileau

11 TECHNICAL FIELD

12 This invention relates in general to wellhead  
13 equipment, and in particular to a production tree having  
14 a tubing hanger therein, the tubing hanger and production  
15 tree having lateral production passages.

16 BACKGROUND ART

17 A conventional subsea wellhead assembly includes a  
18 wellhead housing which supports one or more casing  
19 hangers located at upper ends of strings of casing  
20 extending into the well. A tubing hanger lands in the  
21 wellhead housing above the casing hanger and supports a  
22 string of production tubing that extends through the  
23 smallest diameter casing. The tubing hanger has a  
24 production bore which is offset slightly from the  
25 longitudinal axis. An annulus bore also extends through  
26 the tubing hanger, parallel to and offset from the axis,  
27 for communicating the tubing annulus to above the tubing

1 hanger. The annulus bore is needed during installation  
2 of the tubing hanger and tubing to establish circulation  
3 down the tubing and back up the annulus. After the well  
4 has been completed, a removable plug is installed in the  
5 annulus bore, then a production tree is mounted to the  
6 wellhead housing. Access through the production tree to  
7 the tubing may be made for various workover operations  
8 that are needed.

9 In the last few years, operators have begun  
10 installing a different type of wellhead assembly,  
11 referred to generally as a horizontal tree. In a  
12 horizontal tree, the tubing hanger lands in the tree, not  
13 in the wellhead housing located below the tree. The  
14 tubing hanger has a lateral flow passage extending from  
15 its vertical flow passage. The lateral flow passage  
16 registers with a lateral flow passage extending through  
17 a sidewall of the tree. Gallery seals are employed to  
18 seal the junction between the lateral production  
19 passages. The gallery seals comprise seal rings which  
20 are coaxial with the vertical axis, with one of the seals  
21 located above the lateral passage and the other located  
22 below. The lower seal necessarily will be of a smaller  
23 diameter than the upper seal in order to provide



1 clearances for installation.

2 With the horizontal tree, a tubing hanger can be  
3 pulled through the horizontal tree without removing the  
4 tree. This cannot be done with a conventional tree.  
5 While this is an advantage, one disadvantage is the  
6 horizontal tree tubing hanger has inadequate room to  
7 utilize a vertical annulus passage extending through the  
8 tubing hanger as with a conventional tubing hanger.  
9 Instead, tubing annulus communication is accomplished  
10 generally by utilizing a bypass passage through the tree  
11 from below the tubing hanger and back into the tree above  
12 the tubing hanger. While a bypass passage is workable,  
13 it relies on a valve on the exterior for closing the  
14 annulus. Some operators believe that a removable plug  
15 installed within an annulus passage in a tubing hanger is  
16 safer than a valve.

17 Another disadvantage of a typical horizontal tree  
18 tubing hanger has to do with the need to communicate  
19 auxiliary fluid to downhole equipment. For example,  
20 downhole safety valves are used in a tubing string at  
21 some distance below the surface. A safety valve remains  
22 open so long as it is supplied with hydraulic fluid  
23 pressure. In the absence of fluid pressure, it will

1 close. Consequently, if the production wellhead assembly  
2 is severely damaged, the well would be held under control  
3 through the safety valve. In conventional tree tubing  
4 hangers, passages are drilled through the tubing hanger  
5 from the upper end to the lower end. The upper ends of  
6 the hydraulic passages have connectors which mate with  
7 connectors on the tree to supply hydraulic fluid. In the  
8 horizontal tree, however, this cannot occur because the  
9 tubing hanger lands within the tree, not in the wellhead  
10 housing below.

11 Some manufacturers have drilled ports through the  
12 sidewall of the tree to communicate with hydraulic  
13 passages drilled within the tubing hanger. These  
14 manufacturers have employed gallery type seals to seal  
15 the junctions of the ports. This again requires a  
16 reduction in inner diameter of the bore of the tree.  
17 There may be several ports for auxiliary fluid passages,  
18 requiring several sets of gallery seals. U.S. Patents  
19 5,465,794 and 5,555,935 show ports on the exterior of a  
20 tubing hanger that do not requires gallery seals. These  
21 ports locate on a spherical surface formed on the tubing  
22 hanger and in the bore of the tree.

23

1           SUMMARY OF THE INVENTION

2           In this invention, the tree is of a horizontal type,  
3           having a lateral production passage. A tubing hanger,  
4           also having a lateral production passage, lands in the  
5           tree. The tree has a seal area that surrounds the inlet  
6           of the lateral production passages which is flat and  
7           inclined relative to the axis. The tubing hanger also  
8           has a seal area which is flat and inclined and mates with  
9           the tree seal area. The mating flat surfaces obviate the  
10          need for gallery seals, allowing a larger bore at that  
11          area than in the prior art gallery seal type.

12          Preferably the tubing hanger has an annulus flow  
13          passage that is offset from and parallel to the vertical  
14          production passage in the tubing hanger. The vertical  
15          annulus passage may be accessed from above and will  
16          receive a removable plug after completion. Preferably a  
17          lateral passage extends laterally from the vertical  
18          annulus passage of the tubing hanger and registers with  
19          a lateral annulus passage formed in the tree. The mating  
20          openings of the tree annulus passage are on flat and  
21          inclined sealed areas formed on the tubing hanger and in  
22          the bore of the tree. The lateral annulus passage allows  
23          access to the annulus through a valve as an option.

1           The tree also has an auxiallary passage which  
2 extends through a sidewall of the tree and has an  
3 auxiallary connector which is located on an upward facing  
4 shoulder forming the bore of the tree. The tubing hanger  
5 has a downward facing hydraulic connector which  
6 telescopingly mates with the connector in the tree bore.  
7 The auxiliary passages lead to a downhole safety valve.  
8  
9

10           BRIEF DESCRIPTION OF THE DRAWINGS

11           Figures 1A and 1B comprise a vertical sectional view  
12 of a wellhead assembly constructed in accordance with  
13 this invention.

14           Figure 2 is an enlarged partial sectional view of a  
15 portion of the wellhead assembly of Figures 1A, 1B.

16           Figure 3 is a sectional view of a portion of the  
17 wellhead assembly of Figures 1A, 1B, taken along the line  
18 3-3 of Figure 2, with the left side showing an  
19 installation step and the right side showing the assembly  
20 after installation has been completed.

21           Figure 4 is a sectional view of the wellhead  
22 assembly of Figures 1A, 1B, taken along the line 4-4 of  
23 Figure 1.

1        DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

2                Referring to Figure 1B, a subsea wellhead is shown,  
3        including a tubular low pressure housing 11 that lands in  
4        a guide base 13 supported on the sea floor. Housing 11  
5        is connected to a large diameter conductor extending into  
6        the well to a first depth. A high pressure housing 15  
7        lands in the low pressure housing 11. High pressure  
8        housing 15 is also a tubular member, and it is secured to  
9        a string of casing 17 which extends into the well to a  
10       second depth. A lower casing hanger 19 lands in wellhead  
11       housing 15 and supports a string of casing 21 which  
12       extends into the well to a third depth. An upper casing  
13       hanger 23 lands on top of lower casing hanger 19 and  
14       supports a string of casing 25 which extends to the  
15       bottom of the well in the embodiment shown. Both casing  
16       hangers 19, 23 are conventionally sealed to the bore of  
17       high pressure housing 15.

18               A lower tubing hanger 27 lands in the bowl of the  
19       upper casing hanger 23. Lower tubing hanger 27 is  
20       secured to a string of production tubing 29 which extends  
21       into the well for providing a conduit for the flow of  
22       production fluid. Lower tubing hanger 27 has a vertical  
23       production passage 31 which is coaxial with tubing 29.

1 An annulus passage 33 is also axial or vertical, and  
2 extends alongside production passage 31. Annulus passage  
3 33 is in communication with an annulus space surrounding  
4 tubing 29.

5 Lower tubing hanger 27 is secured conventionally in  
6 upper casing hanger 23 by means of a cam sleeve 35, lock  
7 ring 37, and actuating sleeve 39. Actuating sleeve 39  
8 extends upward above the upper end of lower tubing hanger  
9 27, as shown in Figure 1B, and can be shifted by a  
10 running tool between an upper released position and a  
11 lower locked position. A downhole safety valve 38 is  
12 located in tubing 29 some distance below wellhead housing  
13 11. Safety valve 38 is connected to a hydraulic line 40  
14 which extends upward to lower tubing hanger 27.  
15 Hydraulic pressure in line 40 maintains safety valve 38  
16 in an open position. The absence of hydraulic pressure  
17 in line 40 causes safety valve 38 to close.

18 Referring also to Figure 1A, a christmas tree 41  
19 lands on top of wellhead housing 15. A conventional  
20 hydraulic connector 43 carried by tree 41 connects tree  
21 41 to a grooved profile 45 formed on housing 15 near its  
22 upper end. Tree 41 is a large tubular member that has a  
23 grooved profile 47 on its upper end that is identical to

1 wellhead profile 45. Tree 41 has a production passage 49  
2 that is horizontal, perpendicular to the longitudinal  
3 axis, and extends from its bore 48 to the exterior. A  
4 production master valve 51 controls the flow of  
5 production fluid out tree horizontal passage 49. Tree 41  
6 also has an annulus passage 53 that is horizontal and  
7 perpendicular to the vertical axis. In the embodiment  
8 shown, it is located 180 degrees from and is coaxial with  
9 horizontal passage 49. Tree annulus passage 53 also  
10 extends from the tree bore 48 to the exterior. An  
11 annulus valve 55 can be controlled from the surface for  
12 opening and closing annulus passage 53.

13 Tree 41 is installed by lowering it on guidelines  
14 attached to guide posts (not shown) of guide base 13 in  
15 a conventional manner. As shown in Figure 2, tree 41 has  
16 an orientation sleeve 56 mounted to it that extends  
17 around actuating sleeve 39 of lower tubing hanger 27. A  
18 key 58 on the exterior of lower tubing hanger 27 engages  
19 a slot in orientation sleeve 56. Orientation sleeve 39  
20 orients lower tubing hanger 27 if tubing hanger 27 is  
21 being installed after tree 41 has already been installed.  
22 If lower tubing hanger 27 is installed before tree 41 is  
23 installed, it will be oriented by a conventional method

1 using an orientation internal groove on the BOP stack  
2 wellhead connector.

3 Referring again to Figure 1A, an upper tubing hanger  
4 57 is supported in the bore of tree 41. Upper tubing  
5 hanger 57 has a vertical bore 59 that extends through it  
6 offset from and parallel to the longitudinal axis of tree  
7 41. A lateral passage 61 extends horizontally outward  
8 from vertical bore 59 perpendicular to the vertical axis.  
9 A seat ring 63 is mounted in a counterbore in tree  
10 horizontal production passage 49 at the junction with  
11 tree bore 48. Seat ring 63 is sealed to passage 49 and  
12 has a hole through it that is the same diameter as  
13 passage 49. Seat ring 63 has an inner face 63a that is  
14 flat but inclined relative to the axis of tree 41. The  
15 upper edge of inner face 63a is farther from the axis of  
16 tree 41 than its lower edge. Seat ring 63 is sealed to  
17 passage 49 but is removable. Upper tubing hanger 57 has  
18 a mating seat ring 65 with a flat inclined outer face  
19 that is located at the outer end of lateral passage 61.  
20 Seat ring 65 seals against flat face 63a of seat ring 63  
21 in metal-to-metal sealing engagement.

22 Similarly, upper tubing hanger 57 has an annulus  
23 vertical bore 67 which extends completely through upper



1 tubing hanger 57 offset from and perpendicular to  
2 vertical bore 59. An annulus passage 69 extends  
3 horizontally from vertical bore 67. A seat ring 71  
4 locates sealingly in a counterbore formed in tree annulus  
5 passage 53 at the junction with tree bore 48. Seat ring  
6 71 is constructed the same as seat ring 63, except that  
7 its hole is smaller because the tree annulus passage 53  
8 is smaller in diameter than the production passage 49.  
9 Upper tubing hanger 57 has a seat ring 72 that sealingly  
10 mates with the flat inclined face of seat ring 71.

11 A crown plug 73 of a conventional wireline  
12 retrievable type is installed in upper tubing hanger  
13 vertical bore 59. Crown plug 73 is located above  
14 horizontal passages 61, 49. An annulus plug 75, also  
15 wireline retrievable, is located in annulus vertical bore  
16 67.

17 Referring to Figure 2, a production isolation sleeve  
18 77 is sealingly secured to the lower end of upper tubing  
19 hanger vertical production bore 59. Sleeve 77 extends  
20 sealingly into lower tubing hanger bore 31. An annulus  
21 isolation sleeve 79 secures sealingly to upper tubing  
22 hanger annulus bore 67. Annulus isolation sleeve 79  
23 extends sealingly into lower tubing hanger annulus

1 passage 33. Upper tubing hanger 57 has an orientation  
2 key 81, shown in Figure 2, that engages orientation  
3 sleeve 56 of tree 41. This orients upper tubing hanger  
4 57 relative to tree 41.

5 Referring to Figure 3, a plurality of hydraulic  
6 fittings or connectors 83 are mounted to lower tubing  
7 hanger 27 and face upwardly. Hydraulic connectors 83  
8 connect to hydraulic lines 40 (Fig. 1B) for opening and  
9 closing downhole safety valves 38 (Figure 1B). Female  
10 hydraulic fittings or connectors 83 are secured to the  
11 lower end of upper tubing hanger 57. Hydraulic  
12 connectors 85 will stab over hydraulic connectors 83 to  
13 make up a connection. Belleville springs 87 provide a  
14 positive pressure to retain the connection. Similarly,  
15 hydraulic connectors 89 are located on an upward facing  
16 shoulder 90 in bore 48 of tree 41 outside of where upper  
17 tubing hanger 57 will land. Downward facing female  
18 hydraulic connectors 91 are mounted to upper tubing  
19 hanger 57 to stab onto hydraulic connectors 89 when upper  
20 tubing hanger 57 is installed. Hydraulic connectors 89  
21 are connected to passages which lead to a source of  
22 hydraulic fluid pressure for opening safety valve 38  
23 (Fig. 1B) or performing other auxiliary functions.

1           Connectors 89 are also shown in Figure 4.

2           Referring to Figure 3, upper tubing hanger 57 is  
3           secured in tree bore 48 by a lock member 93 which is  
4           pushed outward by a cam member 95. The left side of  
5           Figure 3 shows upper tubing hanger 57 prior to insulation  
6           while the right side shows upper tubing hanger 57 after  
7           it is completely installed.

8           Referring again to Figure 1A, an internal tree cap  
9           97 locates within tree bore 48 above upper tubing hanger  
10          57. Internal tree cap 97 has two vertical bores 98, 100  
11          which align coaxially with the upper tubing hanger bores  
12          59, 67. Wireline retrievable plugs 99, 101 are located  
13          within the bores 98, 100. A corrosion cap 103 is  
14          installed over the upper end of tree 41 for protection.  
15          Referring to Figure 4, lateral annulus passage 53 leads  
16          to a crossover passage 105 which will selectively connect  
17          annulus passage 53 with the production passage 49.  
18          Valves 107 will control opening and closing of crossover  
19          passage 105.

20          In one mode of operation, after the well has been  
21          drilled and the casing hangers 19, 23 and lower tubing  
22          hanger 27 oriented and installed, the operator can run  
23          christmas tree 41 and secure it by connector 43. The

1 operator then installs upper tubing hanger 57, which  
2 orients by means of its key 81 (Fig. 2) engaging tree  
3 orientation sleeve 56. After testing procedures, the  
4 operator installs wireline retrieval plugs 73, 75,  
5 internal tree cap 97, and wireline retrievable plugs 99,  
6 101. The production fluid will flow up production tubing  
7 29 and out horizontal passage 49.

8 Several workover options are available. In one  
9 mode, a drilling riser having a blowout preventer (not  
10 shown) will land on tree profile 47 after removing  
11 corrosion cap 103. The internal tree cap 97 is removed  
12 through the drilling riser using a recovery string  
13 extending through the riser. Closing the downhole safety  
14 valves (not shown) allows one to remove the wireline  
15 plugs 73, 75. An adapter on the recovery string stabs  
16 into the vertical production bore 59 while the annulus  
17 vertical bore 67 communicates with the drilling riser  
18 annulus around the recovery string and thus with the  
19 riser choke and kill lines once the blowout preventer is  
20 closed around the recovery string. One conduit leading  
21 to the production tubing 29 and one to the annulus space  
22 is then established with the workover vessel.

1           Prior to removing tubing 29, the well ordinarily  
2 must be killed. During this procedure, the well  
3 production fluid is replaced with a heavier fluid. The  
4 operator can kill the well by opening the downhole safety  
5 valve, and pumping down the recovery string and  
6 production tubing 29. The fluid flows out a port at the  
7 lower end of the production tubing 29, back up the tubing  
8 annulus, upper tubing hanger annulus bore 67, and up one  
9 of the choke and kill lines.

10           After the well is killed, the operator can retrieve  
11 production tubing 29 with the recovery string by pulling  
12 upper tubing hanger 57, then pulling tubing hanger 27  
13 along with tubing 29. After the workover operation,  
14 tubing 29 and lower tubing hanger 27 are lowered through  
15 tree 41 and re-installed. Lower tubing hanger 27 will  
16 orient by engagement of key 58 with orientation sleeve 56  
17 (Fig. 2) during the installation. Alternately, the  
18 operator may remove tree 41 without pulling tubing 29.  
19 In this instance, preferably another wireline plug (not  
20 shown) will be installed in a grooved profile in lower  
21 tubing hanger 27 before removing tree 41. When tree 41  
22 is pulled upward, upper tubing hanger 57 and isolation  
23 sleeve 77 will be pulled with tree 41, while tubing

1 hanger 27 and tubing 29 remain in place.

2 Further, the well may be killed in other manners  
3 than described above. Because of the two vertical bores  
4 59 and 67 in upper tubing hanger 57, another method of  
5 killing involves stabbing a completion riser, which has  
6 two strings side by side, into these bores after removal  
7 of the internal tree cap 97 and plugs 73, 75. Also,  
8 killing of the well can be accomplished by use of the  
9 lateral annulus passage 69 and its crossover passage 105  
10 (Figure 4). In this situation, there will be no annulus  
11 conduit back to the vessel. Rather, after communication  
12 is established between the tubing hanger vertical passage  
13 59 and the vessel, production master valve 51 is closed  
14 and annulus valves 55 and 107 (Fig. 4) are opened. Kill  
15 fluid is pumped down the production tubing 29, through a  
16 port (not shown) at the lower end and back up the tubing  
17 annulus. The return fluid flows out annulus horizontal  
18 passage 53, through crossover passage 105 and out the  
19 production line downstream of production master valve 51.

20 The wireline retrievable plugs 73 and 99 allow  
21 various wireline intervention operations without  
22 retrieving either tubing hanger 27, 57 or internal tree  
23 cap 97. During a wireline intervention when the well is

1 not to be killed, downhole safety valve for tubing 29  
2 will be closed to allow wireline plugs 99, 73 to be  
3 removed. The wireline tool will be lowered through a  
4 wireline riser which will be capable of withstanding the  
5 pressure of the well. The wireline riser comprises a  
6 wireline BOP stack mounted to tree 41 to control the well  
7 pressure. After the wireline tool has been lowered into  
8 tubing 29, the downhole safety valve is opened, allowing  
9 the wireline tool to pass through tubing 29.

10 The invention has significant advantages. Utilizing  
11 a flat seal area on the tubing hanger and in the bore of  
12 the tree avoids the need for gallery seals around the  
13 mating lateral passages. This allows a larger diameter  
14 tubing hanger for a particular tree bore than in the  
15 prior art. The larger diameter tubing hanger enables a  
16 vertical annulus passage to be drilled therein, which may  
17 be closed with a removable plug rather than a valve as in  
18 the prior art. The hydraulic connectors which mate when  
19 the tubing hanger lands also avoids the need for gallery  
20 seals.

21 It should be understood that variations to the  
22 embodiment may be made. For example, lower tubing hanger  
23 27 may be eliminated. In that instance, upper tubing

1 hanger 57 would connect directly to production tubing 29.  
2 It would not be possible to remove tree 41 without first  
3 pulling tubing 29, but it would be possible to pull  
4 tubing 29 without retrieving first the tree 41.



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I claim:

1. A well production assembly located at an upper end of a string of tubing extending into a well, comprising:

a production tree having a longitudinal axis, an axial bore, and a lateral production passage, the lateral production passage having an inlet at the bore and extending laterally through a sidewall of the production tree;

a tree seal area in the bore surrounding the inlet of the lateral production passage, the tree seal area being flat and inclined relative to the axis;

a tubing hanger adapted to be located at an upper end of a string of tubing and landed in the bore, the tubing hanger having a vertical production passage extending axially through the tubing hanger and a lateral production passage which extends laterally from the vertical production passage and has an outlet at the exterior of the tubing hanger; and

a tubing hanger seal area on the exterior of the tubing hanger surrounding the outlet of the lateral production passage, the tubing hanger seal area being flat and inclined relative to the axis and mating with the tree seal area, with the outlet registering with the

1 inlet.

2  
3 2. The well production assembly according to claim 1,  
4 further comprising:

5 a tree seat ring installed within the inlet of the  
6 lateral production passage of the tree, the tree seal  
7 area being located on an inward facing side of the tree  
8 seat ring.

9  
10 3. The well production assembly according to claim 1,  
11 further comprising:

12 a tubing hanger seat ring installed within the  
13 outlet of the lateral production passage of the tubing  
14 hanger, the tubing hanger seal area being located on an  
15 outward facing side of the tubing hanger seat ring.

16  
17 4. The well production assembly according to claim 1,  
18 further comprising:

19 a tree seat ring installed within the inlet of the  
20 lateral production passage of the tree, the tree seal  
21 area being located on an inward facing side of the tree  
22 seat ring; and

1           a tubing hanger seat ring installed within the  
2           outlet of the lateral production passage of the tubing  
3           hanger, the tubing hanger seal area being located on an  
4           outward facing side of the tubing hanger seat ring.

5  
6           5. The well production assembly according to claim 1,  
7           further comprising:

8           a vertical annulus passage extending axially through  
9           the tubing hanger offset from and parallel to the  
10          vertical production passage, the vertical annulus passage  
11          having a lower end in communication with a tubing annulus  
12          surrounding the string of tubing and an upper end at an  
13          upper end of the tubing hanger.

14  
15          6. The well production assembly according to claim 1,  
16          further comprising:

17          a vertical annulus passage extending axially through  
18          the tubing hanger offset from and parallel to the  
19          vertical production passage, the vertical annulus passage  
20          having a lower end in communication with a tubing annulus  
21          surrounding the string of tubing;

22          a lateral annulus passage extending laterally  
23          through the tubing hanger from the vertical annulus

1 passage, the lateral annulus passage having an opening on  
2 the exterior of the tubing hanger;

3 a tree annulus passage having an opening in the bore  
4 of the tree and extending laterally through the sidewall  
5 of the tree; and

6 the openings of the lateral annulus passage and the  
7 tree annulus passage having mating annulus seal areas  
8 which are flat and inclined relative to the axis.

9  
10 7. The well production assembly according to claim 1,  
11 further comprising:

12 a tree auxiliary passage extending through the  
13 sidewall of the tree and having a tree auxiliary  
14 connector in the bore which faces generally upward; and

15 a tubing hanger auxiliary passage extending through  
16 the tubing hanger, having a tubing hanger auxiliary  
17 connector on the exterior of the tubing hanger which  
18 faces generally downward and sealingly mates with the  
19 tree auxiliary connector as the tubing hanger lands in  
20 the production tree.

1           8.    A well production assembly located at an upper end  
2           of a string of tubing extending into a well, comprising:  
3                a production tree having a longitudinal axis, an  
4           axial bore and a lateral production passage, the lateral  
5           production passage having an inlet at the bore and  
6           extending laterally through a sidewall of the production  
7           tree;  
8                a tubing hanger landed in the bore and adapted to be  
9           located at an upper end of a string of tubing, the tubing  
10          hanger having a vertical production passage extending  
11          axially through the tubing hanger and a lateral  
12          production passage which extends laterally from the  
13          vertical production passage through the tubing hanger and  
14          has an outlet at the exterior of the tubing hanger which  
15          registers with the inlet of the lateral production  
16          passage of the tree;  
17               a vertical annulus passage extending through the  
18          tubing hanger from a lower end to an upper end of the  
19          tubing hanger offset from the vertical production  
20          passage, the vertical annulus passage having a lower end  
21          adapted to be in communication with a tubing annulus  
22          surrounding the string of tubing;

1           a removable production plug installed in the  
2 vertical production passage above the lateral production  
3 passage of the tubing hanger; and

4           a removable annulus plug installed in the vertical  
5 annulus passage.  
6

7           9. The well production assembly according to claim 8,  
8 further comprising:

9           a removable internal tree cap which sealingly  
10 engages the bore of the tree above the tubing hanger, the  
11 tree cap having a vertical production passage and a  
12 vertical annulus passage which are offset from and  
13 parallel to each other, the vertical production passage  
14 of the tree cap aligning with the vertical production  
15 passage of the tubing hanger, the vertical annulus  
16 passage of the tree cap aligning with the vertical  
17 annulus passage of the tubing hanger;

18           a removable production plug installed in the  
19 vertical production passage of the tree cap; and

20           a removable annulus plug installed in the vertical  
21 annulus passage of the tree cap.

1           10. The well production assembly according to claim 8,  
2           further comprising:

3                 a lateral annulus passage extending laterally  
4           through the tubing hanger from the vertical annulus  
5           passage, the lateral annulus passage having an opening on  
6           the exterior of the tubing hanger; and

7                 a tree annulus passage having an opening in the bore  
8           of the tree and extending laterally through the tree for  
9           sealingly registering with the opening of the lateral  
10          annulus passage of the tubing hanger.

11

12           11. The well production assembly according to claim 8,  
13           further comprising:

14                 a tree seat ring installed within the inlet of the  
15           lateral production passage of the tree, the tree seat  
16           ring having a flat seal area located on an inward facing  
17           side of the tree seat ring, the seal area being inclined  
18           relative to the longitudinal axis; and

19                 a tubing hanger seat ring installed within the  
20           outlet of the lateral production passage of the tubing  
21           hanger, the tubing hanger seat ring having a flat seal  
22           area located on an outward facing side of the tubing  
23           hanger seat ring which sealingly engages the seal area on

1 the tree seat ring.

2  
3 12. A well production assembly, comprising:

4 a production tree having a longitudinal axis, an  
5 axial bore, and a lateral production passage, the lateral  
6 production passage having an inlet at the bore and  
7 extending laterally through a sidewall of the production  
8 tree;

9 a tree seat ring installed within the inlet of the  
10 lateral production passage of the tree, the tree seat  
11 ring having on an inward facing side a tree seal area  
12 which is flat and inclined relative to the axis;

13 a string of tubing extending into the well;

14 a tubing hanger connected to an upper end of the  
15 string of tubing and landed in the bore, the tubing  
16 hanger having a vertical production passage extending  
17 axially through the tubing hanger and a lateral  
18 production passage which extends laterally from the  
19 vertical production passage through the tubing hanger,  
20 the lateral production passage of the tubing hanger  
21 having an outlet at the exterior of the tubing hanger;



1           a tubing hanger seat ring installed the outlet of  
2           the lateral production passage of the tubing hanger, the  
3           tubing hanger seat ring having a tubing hanger seal area  
4           located on an outward facing side of the tubing hanger  
5           seat ring which sealingly mates with the tubing hanger  
6           seat ring;

7           a vertical annulus passage extending axially through  
8           the tubing hanger offset from and parallel to the  
9           vertical production passage, the vertical annulus passage  
10          having a lower end in communication with a tubing annulus  
11          surrounding the string of tubing and an upper end at an  
12          upper end of the tubing hanger;

13          a removable production plug installed in the  
14          vertical production passage above the lateral production  
15          passage; and

16          a removable annulus plug installed in the vertical  
17          annulus passage.

18

19          13. The well production assembly according to claim 12,  
20          further comprising:

21          a lateral annulus passage extending laterally  
22          through the tubing hanger from the vertical annulus  
23          passage, the lateral annulus passage having an opening on

1 the exterior of the tubing hanger;

2 a tree annulus passage having an opening in the bore  
3 of the tree and extending laterally through the tree;  
4 and

5 the openings of the tubing hanger and the tree  
6 having mating annulus seal areas which are flat and  
7 inclined relative to the axis.

8  
9 14. The well production assembly according to claim 12,  
10 further comprising:

11 a tree auxiliary passage extending through the  
12 sidewall of the tree and having a tree auxiliary  
13 connector in the bore which faces generally upward; and

14 a tubing hanger auxiliary passage extending through  
15 the tubing hanger, having a tubing hanger auxiliary  
16 connector on the exterior of the tubing hanger which  
17 faces generally downward and sealingly mates with the  
18 tree auxiliary connector as the tubing hanger lands in  
19 the production tree to communicate the tree auxiliary  
20 passage with the tubing hanger auxiliary passage.

1        15. A well production assembly comprising in  
2        combination:

3                a production tree having a vertical axis, an axially  
4        extending bore, and a lateral production passage  
5        extending from the bore through a sidewall of the tree  
6        transverse to the vertical axis;

7                a generally upward facing shoulder formed in the  
8        bore;

9                a tree auxiliary passage extending through the  
10        sidewall of the tree and having an auxiliary connector  
11        located at the upward facing shoulder;

12               a string of tubing extending into a well;

13               a tubing hanger which lands sealingly in the bore  
14        and is connected to the string of tubing, the tubing  
15        hanger having a lateral production passage extending from  
16        an axial production passage, the lateral production  
17        passage aligning with the lateral production passage of  
18        the tree; and

19               a tubing hanger auxiliary passage extending through  
20        the tubing hanger, having an auxiliary connector which  
21        telescopingly and sealingly mates with the auxiliary  
22        connector in the tree when the tubing hanger lands, to  
23        communicate the tree auxiliary passage with the tubing

1 hanger auxiliary passage.

2  
3 16. The well production assembly according to claim 15,  
4 wherein each of the auxiliary connectors has an axis, and  
5 wherein the axes of the auxiliary connectors coincide  
6 when mated.

7  
8 17. The well production assembly according to claim 15,  
9 wherein:

10 the auxiliary connector of the tree is a tubular  
11 member which protrudes upward from the upward facing  
12 shoulder; and

13 the auxiliary connector of the tubing hanger is a  
14 tubular member which protrudes downward from the tubing  
15 hanger.

16  
17 18. The well production assembly according to claim 15,  
18 wherein:

19 the auxiliary connector of the tree is a tubular  
20 member which protrudes upward from the upward facing  
21 shoulder; and

22 the auxiliary connector of the tubing hanger is a  
23 tubular receptacle which protrudes downward from the

1 tubing hanger and slides over the auxiliary connector.

2

3 19. The well production assembly] according to claim 15,  
4 further comprising:

5 a downhole safety valve connected into the tubing  
6 string for selectively interrupting fluid flow through  
7 the tubing string; and

8 a hydraulic line extending from the downhole safety  
9 valve to the tubing hanger auxiliary passage for  
10 receiving hydraulic fluid pressure from the tree  
11 auxiliary passage to actuate the downhole safety valve.

12

13 20. The well production assembly according to claim 15,  
14 wherein the auxiliary connectors of the production tree  
15 and the tubing hanger are parallel to the vertical axis.



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Claims searched: 1-7, 12-14

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Patents Act 1977  
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): E1F: FJR

Int Cl (Ed.6): E21B 33/04, 33/043

Other: Online WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2166775 A (BRITOL PLC) see figure 1, in particular parts 10 and 11	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.